In the Specification:

After the title, insert:

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. Application No. 09/298,272, filed ~~April 23, 1999, now U.S. Patent No. 6,142,924,~~ which claims the benefit of U.S. Application No. 08/950,377, filed October 14, 1997, now U.S. Patent No. 5,944,648, which claims the benefit of U.S. Provisional Application No. 60/028,556, filed October 15, 1996.

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Please replace the paragraph beginning at page 6, line 2, with the following rewritten paragraph:

A concentric tubular centrifuge 20, as shown and depicted in FIGS. 1-18, is designed to continuously separate large volumes of sludge, such as waste water and oil well drilling fluids. The centrifuge 20 is constructed of at least two laterally opposed, axially aligned arms 22 which extend perpendicularly outwardly from a vertical center main shaft 24 (FIG. 2). The main shaft and arms form a housing, which is supported by a frame 60. The centrifuge is driven by an external motor to rotate about a longitudinal or vertical axis 27 of the center main shaft which develops the centrifugal forces necessary for operation. The centrifuge preferably operates in the range of 600-2000 rpm, depending on its overall size.

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Please replace the paragraphs beginning at page 9, line 5, with the following rewritten paragraphs:

In greater detail, the concentric tubular centrifuge 20 of the present invention is shown in FIG. 1. A frame 60 supports the centrifuge of the present invention for rotational movement of the centrifuge about a vertical axis 27. The centrifuge comprises a housing 62 journaled in the frame with a drive means 64, such as a beveled ring gear drive, attached to the top of the housing for engagement with a drive motor of any known type. The bottom end of the housing is also journaled in the frame for rotational movement, with the bottom end of the housing being surrounded by a decanted fluid catch basin 66 defining a fluid outlet, as further described below. A drive motor (not shown) is positioned in engagement with the drive means 64, in this case the beveled ring gear drive, to engage the drive means to rotate the housing 62 about the vertical axis. In the configuration shown in FIG. 1, the housing rotates about the vertical axis 27 with the arms 22 moving into and out from the plane of the figure.

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Referring now to FIG. 2, the centrifuge housing 62 comprises the center main shaft 24 (FIGS. 2, 7 and 11) having an axially oriented cylindrical bore 82 formed therethrough along with a large centrally positioned cylindrical chamber 70. Also included in the housing are laterally extending arm housings 72 (FIGS. 2, 3, 4, 7 and 8), which have a cylindrical shape with a first open end 74 attached by an annular flange 76 to the center main shaft 24, and a distal or second open end 78. The second open end defines an outwardly extending annular flange 80. Each arm housing 72 defines a cylindrical cavity 82. A frustoconically-shaped end cone 84 is removably attached to the flange 80 at the distal end of each of the arm housings to form an internal chamber in conjunction with the arm housing. An externally threaded aperture 86 (FIG. 4) is formed at the apex 88, or frustrum, of the end cone 84, and receives a correspondingly internally threaded cap end 90 for releasable attachment thereto.

Please replace the paragraph beginning at page 10, line 13, with the following rewritten paragraph:

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The drive means 64, in this case a beveled ring gear drive, mounts around the upper end of the top cylindrical portion of the center main shaft 24. An upper portion of the frame 60 rotationally engages the top cylindrical portion of the center main shaft by way of a bearing means 100, such as tapered roller bearings, to facilitate the rotation of the housing 62 within the frame 60. A similar bearing construction is utilized to rotationally attach a lower portion of the frame to the bottom cylindrical portion of the center main shaft. The centrally positioned chamber 70 (FIG. 11) of the center main shaft 24 receives the fluid and solid transfer manifold 102 (FIG. 10), which is described in greater detail below.

Please replace the paragraph beginning at page 11, line 3, with the following rewritten paragraph:

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Referring to FIGS. 2 and 8, a catch basin 66, which acts as a decanted fluid reservoir and drain channel, attaches to the frame 60 and forms an annular fluid collector about the bottom cylindrical extension 96. The catch basin sealingly engages the bottom cylindrical extension adjacent to and below the apertures forming the channel. A fluid outlet port 114 is formed in the floor of the catch basin to allow drainage of the decanted fluid. The catch basin has a circular tub shape defining a rim 116, from which extends an annular flange 118. The catch basin is attached to the frame by any known means, such as bolts 119 attached through the flange to the frame. A catch basin lid 120 is attached in fixed engagement with the bottom cylindrical portion of the center main shaft and defines a perimeter which sealingly engages the side walls 122 of the catch basin. As the centrifuge rotates within the frame about its vertical axis, the catch basin remains stationary while the bottom cylindrical portion of the center main shaft rotates, and while the catch basin lid 120 also rotates in sealing engagement with the walls 122 of the catch basin.

Please replace the paragraphs beginning at page 11, line 24, with the following rewritten paragraphs:

Referring to FIGS. 2 and 10, the fluid and solid transfer manifold 102 is shown. The fluid and solid transfer manifold has a cylindrical main body which is sized to fit in the central cylindrically shaped chamber 70 of the center main shaft 24 (FIG. 11). The fluid transfer manifold 102 defines a first axial bore 130 formed through a top portion of the manifold and terminates therein. Opposing and laterally extending side bores 132 are formed in communication with the first axial central bore 130, the side bores extending through opposing side walls to act in fluid communication with the arm housing, as is described in further detail below. The first axial bore 130 and associated side bores 132 form a portion of the incoming flow path.

A second axially aligned central bore 134 extends from the bottom surface of the manifold 102 through the central portion of the manifold and terminates prior to joining with the first central bore 130 described above. The top end of the second axial bore 134 communicates with opposing laterally extending bores 136 for receiving a motion transfer means 138 (FIG. 4). The motion transfer means can be a gear and bearing box used to drive the conveyor screw arms 34 off of the main conveyor screw arm 38, as is described in greater detail below. A pair of angled bores 140 are formed each through a side wall of the manifold and extend at an angle downwardly to communicate with the second axial bore 134. The angled bores 140 form a portion of the solids or heavier material exit flow path 52, as described below. A pair of drain channels 142 have an L-shape, with each channel extending from the side wall to the bottom wall of the manifold 102, and form a portion of the decanted fluid exit path 106 for use in draining the decanted liquid from the arm housings 72, as is described in greater detail below. Other entrance, drain and exit channel configurations can be utilized depending on the structure of the device.

Referring to FIGS. 2, 3, 4, 8 and 13, a baffle 56, one of which extends laterally from each side of the manifold 102, is partially inserted into the centrally positioned chamber 70 in the center main shaft 24. Each baffle 56 includes a base 146 having a first side surface 148 and a second side surface 150, and a plurality of concentric cylindrical tubes 28 attached to the second side surface 150 and extending perpendicularly therefrom. The cylindrical tubes have varying lengths and are positioned to alternate between long and short tubes in their concentric configuration. Preferably, the shortest tubes are all of equal length, with tubes of ever-increasing length being alternately positioned between the shortest tubes with the length of the tubes increasing from the largest diameter tube to the smallest diameter tube. With specific reference to the embodiment shown in FIG. 13, six tubes are used to form the preferred embodiment. It is contemplated that a different number of tubes can be utilized depending on the desired structural and performance characteristics. Three of the tubes, the shorter tubes, are all of equal length, while the other tubes increase in

length as their diameter decreases. The concentric tubes are spaced apart a predetermined distance to allow sufficient fluid flow through the flow path defined by the tubes, described in greater detail below. Preferably, the spacing is approximately 0.5 inches, and the lengths between the tubes can be any of a variety of offset dimensions as desired.

A first channel 152 is formed through the base member 146 from the second side 150 to the first side 148, and communicates with the gap 154 formed between the innermost tube 156 and the adjacent second innermost tube 158. This channel 152 forms a part of the incoming flow path 160. A forked channel 162 is formed through the base 146 and communicates with the longitudinal channel 164 defined by the innermost tube 156, with one fork 166 oriented at an angle ownwardly, and the other fork 168 extending in an axial orientation through the base member. A third channel 170 is formed through the base member to open in the space between the outermost tube 172 and the arm housing 72 (FIG. 4).

The concentric tubes 28 are attached to the base member 146. Referring to FIG. 9, the shortest tubes 176 alternating between the longer tubes 178 are sealed about the entire circumference of the end attached to the base member 146 in a fluid-tight manner. The alternately positioned longer tubes 178 are attached to the base member in discrete positions 180 along the circumference of the end 182 adjacent to the base member, such as at every 90 degree increment as shown in FIG. 9. The gap 184 formed between the majority of the circumference of the end of the tube attached to the base member allows fluid to flow from the inside of the tube to the outside of the tube, as is necessary for the serpentine flow path, which is explained in greater detail below.

The base member 146 has a circular shape defining a circumference which is concentrically spaced from the outermost tube 172 of the baffle 56. The base member is positioned in the central chamber 70 of the center main shaft 24 such that the first side 148 of the base member is adjacent to and engages the corresponding side of the fluid transfer manifold 102, as shown in FIG. 4. The baffle member is held in this position by a clamping force provided by the attachment of the arm housing 72 to the center main shaft 24.

As shown in FIGS. 2 and 4, the first channel 152 formed through the base member communicating with the space between the innermost 156 and second innermost tube 158 is aligned with the radially extending channel 132 formed in the manifold, which in turn communicates with the first axial bore 132 formed in the manifold, and continues in communication with the axial bore 68 in the upper cylindrical extension 96 of the center main shaft 24. This series of channels form the incoming flow path 160 (FIG. 6). The interfaces between the base member 146, manifold 102 and the center main shaft 24 are sealed, such as by O-ring seals, to isolate the incoming flow channel and avoid leakage along the interfaces.

The angled bore 166 in the base member 146 is aligned and fluidly communicates with the angled bore 140 of the manifold 102, and continues in fluid communication with the second central bore 134 formed in the manifold, which is in turn aligned with the axial bore 186 through the lower cylindrical extension 96 of the center main shaft 24. The channel 168 located in an axial position with respect to the innermost tube is aligned with the channel 136 which houses the transfer means in the manifold, which in turn is in alignment with the second centered bore 134 of the manifold and the axial bore 186 through the lower cylindrical extension 96. This series of channels forms the heavier material exit path 52 (see FIG. 6).

The channel 170 formed through the bottom of the base member 146 outside the outermost tube 172 is aligned with the L-shaped channel 142 formed in the manifold, which is in turn aligned with the channel 106 formed in the lower cylindrical extension 96 of the center main shaft 24. This series of channels forms the decanted liquid drain channel 46 emptying into the basin 66 (FIG. 8). The channels and bores aligned between and communicating through the base member, manifold and main shaft, are separated by seals, such as O-rings, at the interface between the members to isolate the flow and avoid leakage along the interface.

The manifold 102, baffles 56 and arm housings 72 are mounted on the main shaft 24. The arm housing is shown in FIGS. 2, 3, 4 and 8. When assembled, the flange 76 at the first end meets with the annular shoulder formed around the central chamber 70 of the center main shaft 24, in addition to a circumferencial portion 190 of the base member of the baffle. Elongated bolts 192 having opposing threaded ends are positioned through continuous bores formed in the flange 76 at the first end 74 of the arm housing 72, through the center main shaft 24, and through the opposing and identical flange 76 of the second arm housing. Nuts 194 are threaded and engaged to the opposite ends of the elongated bolts 192 to firmly and releasably clamp the arm housing to the center main shaft 24, which clamps the manifold 102 between the opposing base members 146 positioned on either side of the manifold in the central chamber 70 of the center main shaft. The engagement of the flange 76 at the first end 74 of the arm housing 72 and the circumferencial band 190 of the base member 146 of the baffle member 56 is hermetically sealed by an O-ring 196. A plurality of bolts 192 are positioned through the flange 76 at the first end of the arm housing 72 and through the center main shaft 24 to affix the arm housing to the center main shaft and clamp the base members 146 of the baffles and manifold in the proper position. The baffles 56, manifolds 102 and arm housings 72 are able to be removed from the main shaft 24 simply by removing the bolts 192 in the flanges 76 of the arm housings 72.

Please replace the paragraph beginning at page 18, line 17, with the following rewritten paragraph:

Since each of the concentric tubes 28 of the baffle member 56 are cylindrical in shape, the volume between the tubes is also cylindrical in shape (see FIGS. 8 and 9). The fluid and sludge can flow anywhere in the particular gap between adjacent

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tubes. The decanted fluid 44 flows into the fluid outlet channel 46 from anywhere in the volume between the sixth tube and the arm housing. The outlet channel 46 is formed by the channel 170 through the base member 146 of each baffle, through the L-shaped channel 142 in the manifold, and continuing through the fluid drain channel 106 formed in the lower cylindrical extension 96 of the center main shaft 24. The decanted fluid flows through the outlet channel 46 and into the catch basin 66. The decanted fluid then flows through the outlet 212 (FIG. 2) formed in the base of the catch basin 66 into another reservoir or the conduit for further processing (not shown).

Please replace the paragraph beginning at page 21, line 14, with the following rewritten paragraph:

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The arm conveyor screws 34 are driven from the main conveyor screw 38 by the transfer means 138, such as the gear box, as shown in FIGS. 2, 3, 4, 5, and 6. The gear box includes a master beveled gear 220 and two slave beveled gears 222, one slave gear 222 being associated with each arm conveyor screw 34. Preferably, the top of the main conveyor screw 38 defines the master beveled gear; The rotation of the master beveled gear 218 about the vertical axis 27 translates into rotation about the horizontal axis of each of the slave beveled gears 222. The slave beveled gears 222 are each attached to a shank 224 supported by a journal bearing 226 in the gear box to extend laterally outwardly. The outer end of each of the shanks defines a recess 228 for releasably receiving the inner ends of the arm conveyor screws 34 in a torque transferring manner, such as by interlocking spline teeth. The master gear 220 is attached to a shank 230 supported by journal bearings 232 in the gear box, and which extends vertically downwardly. The outer end of the master shank 230 forms a recess 234 for releasably receiving the top end of the main conveyor screw 38 in a torque-transferring relationship, such as by interlocking spline teeth.

Please replace the paragraph beginning at page 22, line 24, with the following rewritten paragraph:

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The frame 60 supports the centrifuge 20 of the present invention to allow the rotation of the centrifuge about its vertical axis. The frame also facilitates handling the centrifuge to move it from place to place, as well as providing a basic safety function in keeping items away from the rotating housing.

Please replace the paragraph beginning at page 23, line 4, with the following rewritten paragraph:

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The centrifuge 20 structure of the present invention is also easily assembled and disassembled for replacing worn parts as well as modifying the length of the baffles 56 as desired. The arm conveyor screws 34 can be removed by simply removing the end cap 90 from the end cones 84, removing the thrust plate 238 (see

FIG. 12) and extracting the conveyor screw 34 from the center tube 32. The inner end of the arm conveyor screw 34 will disengage from the cavity 228 (see FIG. 5) formed in the shank 224 of the gear box since the cavity (recess) in the shank is designed to transmit torsional forces only, and is not designed to restrain the arm conveyor screw 34 from axial or longitudinally outward movement. The main conveyor screw 38 can similarly be removed by disconnecting the conveyor screw bracket 124 and extracting the main conveyor screw 38 from the gear box in a similar manner. The baffles 56 can be removed or replaced by disconnecting the arm housing 72 from the center main shaft 24, which allows the baffles 56 to simply be extracted from the centrally positioned cavity 70 of the center main shaft 24. The baffle 56 can then be changed to include more or fewer tubes 28 depending on the desired residence time of the sludge under the centrifugal forces, and the level of decanting desired. The length of the centrifugal arms 22 can be adjusted to generate higher or lower separating forces for a given revolution rate. Alternatively, the revolution rate can be increased. A new or different baffle 56 can be repositioned therein with the arm housing 72 being remounted to the center main shaft 24 for further use.

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Please replace the paragraph beginning at page 24, line 5, with the following rewritten paragraph:

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A second embodiment of the present invention is described hereafter and is referenced in FIGS. 14-18. In the second embodiment, the inflow channel 250, outflow channel 252 and decanted liquid exit channel 254 are all substantially the same structure as in the previous embodiment. In addition, the catch basin 256, frame 258, and primary conveyor rod 260 are also substantially the same as the previously described embodiment.

Please replace the paragraph beginning at page 26, line 7, with the following rewritten paragraph:

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A conveyor screw bracket 292 is fixed to the bottom of the catch basin 256 and extends to a central position aligned with the axial bore 272 formed through the center main shaft 262 for fixedly receiving an end of the main or primary screw.

Please replace the paragraph beginning at page 27, line 7, with the following rewritten paragraph:

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Referring to FIGS. 14, 15 and 18, the baffle 300 includes a base 314 having a first side surface 316 and a second side 318 surface and a plurality of concentric cylindrical tubes 320 attached to the second side surface and extending perpendicularly therefrom. The base 314 of the baffle 300 is partially inserted into the centrally positioned chamber 274 in the center main shaft 262, and extends laterally from each side of the manifold 282. A first channel 322 is formed through the base

member 314 from the second side 318 to the first side 316, and communicates with the gap space 324 between the inner 326 and outer 328 cylindrical tubes attached to the base 314. This channel 322 forms part of the incoming flow path 250. A forked channel 330 is formed through the base 314 and communicates with the longitudinal channel 332 defined by the inner tube 326, with one fork 334 oriented at an angle downwardly, and the other fork 336 extending in an axial orientation through the base member 314. A third channel 338 is formed through the base member 314 and is external to the outermost tube 328. Both the inner 326 and outer 328 cylindrical tubes are sealed entirely about the circumference of the end attached to the base member 314. The baffle 300 is preferably made of a lightweight material that is corrosive-resistant and relatively strong, such as plastic.

The base member 314 has a circular shape defining a circumference which is concentrically spaced from the outermost tube 328 of the baffle 300. The base member 314 is positioned in the central chamber 274 of the main shaft 262 such that the first side 316 of the base member 314 is adjacent to and engages the fluid transfer manifold 282, as is shown in FIGS. 14 and 15. The baffle 300 is held in this position by a clamping force provided by the through-bolts 340 used to connect the entire assembly, as described further below. As shown in FIGS. 14 and 15, the first channel 322 formed through the base member 314 is aligned with the radially extending channel 298 formed in the manifold 282, which in turn communicates with the first axial bore 294 formed in the manifold 282, and continues in communication with the axial bore 272 in the upper cylindrical extension 266 of the center main shaft 272, and thus forms the inlet flow path 250.

The angled bore 334 in the base member 314 is aligned and fluidly communicates with the angled bore 310 of the manifold 282, and continues in fluid communication with the second central bore 302 formed in the manifold 282, which is in turn aligned with the axial bore 272 through the lower cylindrical extension 268 of the center main shaft 262. The channel 336 located in an axial position with the respect to the innermost tube 326 is aligned with the channel 302 which houses the transfer means 306 in the manifold. This series of channels forms the outlet flow path 252. The third channel 338 formed through the base member 314 outside the outermost tube 328 is aligned with the L-shaped channel 312 formed in the manifold 282, which is in turn aligned with the decanted liquid drain channel 284 formed in the lower cylindrical extension 268 of the center main shaft 262. This series of channels forms the decanted water flow exit path 254. The channels and bores aligned between and communicating through the base member 314 and the manifold 282 are separated by seals 342, such as by O-rings, at the interface between the base member 314 and the manifold 282.

Please replace the paragraph beginning at page 30, line 19, with the following

rewritten paragraph: